microwave signal would be amplified and applied to the input terminal of an electro-optical modulator, which would impress the microwave signal as modulation onto a beam of light. The light would enter a Bessel-beam fiber-optic element, which is essentially an optical waveguide that tapers to a wider aperture at its output end. A Bessel-beam fiber-optic element acts as a highly dispersive radiator horn, roughly equivalent to a bundle of optical fibers of different lengths. The dispersion in a Bessel-beam fiber-optic element is so great as to afford delays ranging from about 10 ps to about 1 μs. In this instrument, the light arriving at each location on the output plane of the dispersive optical element would have a different delay, and so an array of photodiodes would be placed on that output plane to sample signals at various increments of delay. The variously delayed microwave outputs of the photodiodes would be used to obtain the required autocorrelation data.

This work was done by Anatoliy Savchenkov, Andrey Matsko, Dmitry Strekalov, and Lute Maleki of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-43992, volume and number of this NASA Tech Briefs *issue, and the page number.*

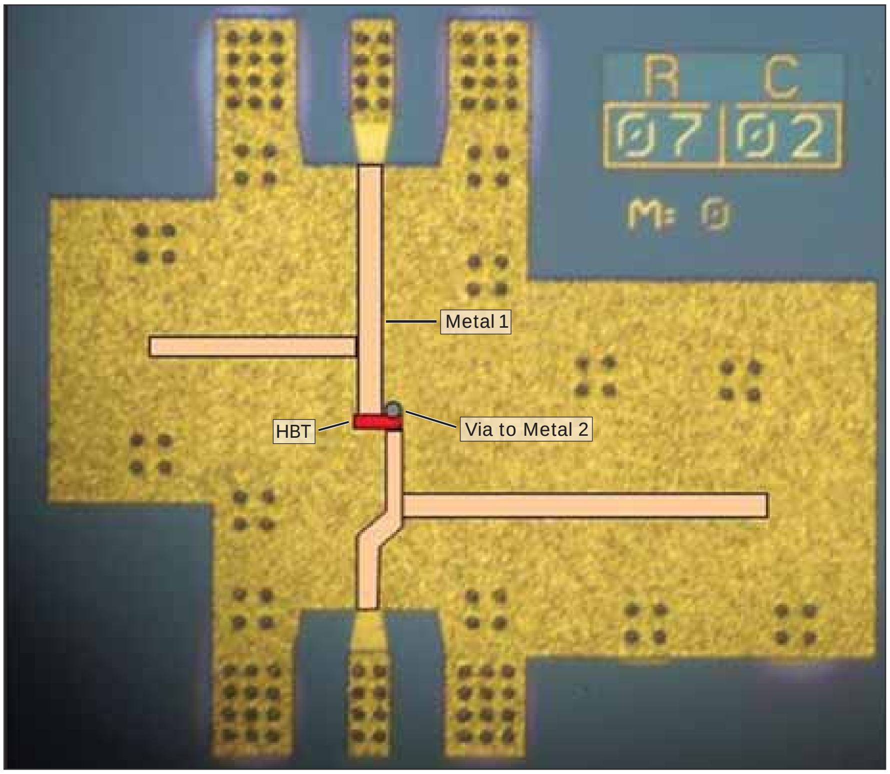
InP Heterojunction Bipolar Transistor Amplifiers to 255 GHz

These amplifiers can be used in millimeter-wave imaging systems for weapons detection and airport security, and for radar instruments.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two single-stage InP heterojunction bipolar transistor (HBT) amplifiers operate at 184 and 255 GHz, using Northrop Grumman Corporation's InP HBT MMIC (monolithic microwave integrated circuit) technology. At the time of this reporting, these are reported to be the highest HBT amplifiers ever created. The purpose of the amplifier design is to evaluate the technology capability for high-frequency designs and verify the model for future development work.

MMIC amplifier operating frequencies have pushed past 200 GHz and into submillimeter wave frequencies. The main driver has been in demand for millimeter-wave radiometers and high-resolution, all-weather imaging systems.



A microphotograph shows the **255-GHz Amplifier MMIC**. A second metal serves as a ground plane and covers most of the circuit area. The transmission lines and HBT device are "drawn" in the photograph. Die size is 0.55 mm × 0.55 mm.

MMIC power amplifiers have a variety of applications for ground-based and future space-based telescopes for astrophysics, as well as in local oscillators for heterodyne receivers in Earth and planetary science instruments. They can be used in millimeter-wave imaging systems to provide sensitive hidden-weapons detections, airport security imaging systems, or other homeland security portable imaging sensors. Power amplifiers can also be used in transmitters for radar instruments and commercial laboratory power sources.

While HEMT amplifiers are traditionally used for low noise receivers due to their low noise properties, HBT amplifiers can be used as power sources due to the nature of their material properties, traditionally higher breakdown voltages and potentially higher efficiency.

A demonstration of the MMIC HBT amplifier showed results approaching the sub-millimeter-wave regime (~300 GHz) and showed the highest reported gain of 3.5 dB for a single-stage HBT amplifier at 255 GHz. The common emitter topology was chosen due to its stability at high frequencies. Distributed transmission lines and matching components were realized using an inverted microstrip configuration, and were implemented in a two-metal process with BCB (benzocyclobutene) dielectric. The primary advantage of this configuration is low inductance to ground compared with traditional microstrip designs.

This work was done by Vesna Radisic, Donald Sawdai, Dennis Scott, William Deal, Linh Dang, Danny Li, Abdullah Cavus, Richard To, and Richard Lai of Northrop Grumman Corporation, and Lorene Samoska, King Man Fung, and Todd Gaier of Caltech for NASA's Jet Propulsion Laboratory. The contributors would like to acknowledge the support of Dr. Mark Rosker and the Army Research Laboratory. This work was supported by the DARPA SWIFT Program and Army Research Laboratory under the DARPA MIPR no.06-U037 and ARL Contract no. W911QX-06-C-0050. NPO-45465

Combinatorial Generation of Test Suites

NASA's Jet Propulsion Laboratory, Pasadena, California

Testgen is a computer program that generates suites of input and configuration vectors for testing other software or software/hardware systems. As systems become ever more complex, often, there is not enough time to test systems against all possible combinations of inputs and configurations, so test engineers need to be selective in formulating test plans. Testgen helps to satisfy this need: In response to a test-suite-requirement-specification model, it generates a minimal set of test vectors that satisfies all the requirements.

Testgen generates test cases following a combinatorial approach, but instead of generating all possible combinations across all test factors, it generates a test suite covering all possible combinations among user-specified groups of test factors. Testgen affords three main benefits:

- The level of coverage of the test space can be increased or decreased easily by modifying the test model. Hence, the rigor of testing can be adjusted according to availability of time and resources.
- Within a test model, degrees of combinations can be adjusted separately for different subsystems.
- Typically, Testgen generates test cases in seconds, whereas manual generation of the same test cases takes hours, and Testgen never omits desired combinations or includes redundant test cases.

This program was written by Anthony C. Barrett and Daniel L. Dvorak of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-45921.